

# ***Robust Mobility Modeling (RMM)***

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# *RMM: Presentation Overview*

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**Problem Definition**  
**Purpose & Scope**  
**Research Objectives**  
**Approach**  
**Milestones**  
**Ongoing Activities**  
**Summary**



Mobility Systems Division

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# ***RMM: Problem Definition***

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- **Previous off-road mobility modeling efforts focused on maximum speed potential (e.g., NRMM)**
- **Modeling off-road mobility at less than 100% throttle and on a high-fidelity scale for multiple passes is critical for**
  - **virtual environments**
  - **procurement**
  - **training**
- **Scenes and images can be readily produced but will not meet the needs of the vehicle developer or training environment unless the physics is realistically portrayed**



# ***RMM: Purpose & Scope***

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- **Purpose: model soil - tire / track interaction for a vehicle moving along a traverse**
- **Involves characterizing inter-relationships between**
  - ◆ **load distribution**
  - ◆ **sinkage**
  - ◆ **motion resistance**
  - ◆ **slip**
  - ◆ **tractive force**
  - ◆ **soil properties**
- **Scope:**
  - **off-road vehicle mobility**
  - **wheeled and tracked vehicles**
  - **straight-line motion**
  - **deformable soil conditions**



# ***RMM: Research Objectives***

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- **Develop load-sinkage and traction-slip algorithms to describe soil-track or soil-tire interaction**
  - **theoretically based**
  - **validated with field testing**
- **Produce a mobility modeling capability by integrating algorithms into existing vehicle dynamics platforms**
  - **incorporate traverse characteristics**
  - **portable to various models/systems**
  - **capable of evaluating concept vehicles**
- **“Put physics behind the scenes”**



# ***RMM: Approach***

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- **Utilize readily available parameters (e.g., cone index)**
- **Incorporate effects of repeated loading on soils**
- **Employ dynamically loaded footing analogy**
- **Generate time history of load distribution from vehicle dynamics models**
- **Couple soil response and vehicle dynamics models to create action-reaction sequences**



## ***RMM: Milestones***

### ***FY93-96 Accomplishments***

- **Developed load-sinkage algorithms for wheeled and tracked vehicles**
- **Conducted ongoing validation of algorithms via field tests**
- **Developed traction-slip relationships for wheeled and tracked vehicles**
- **Integrated traction-slip algorithms for wheeled and tracked vehicles into RMM**
- **Coupled soil response algorithms with vehicle dynamics model**
- **Developed demonstration capability on VEHDYN platform**
- **Investigated utility of Weighmat technology jointly with Airfields and Pavements Division**



# ***RMM: FY97 Milestones***

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- **Validate traction/slip algorithms for tracked and wheeled vehicles for integration into RMM.....3Q97**
- **Complete development of robust theoretical mobility modeling set incorporating non-linear and hysteretic vehicle-terrain interaction.....4Q97**
- **Complete validation of RMM algorithms.....4Q97**





# ***RMM: Ongoing Activities***

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- **Field validation and data collection**
  - multiple measurements along a traverse
  - measure wheel speed, vehicle speed, throttle position, tractive force, cone index, and sinkage
  - evaluate left and right ruts at several stations
- **Integration of traction-slip relationships into soil response - vehicle dynamics platform**
  - acceleration/deceleration
  - variable throttle position



## ***RMM: Field Tests***

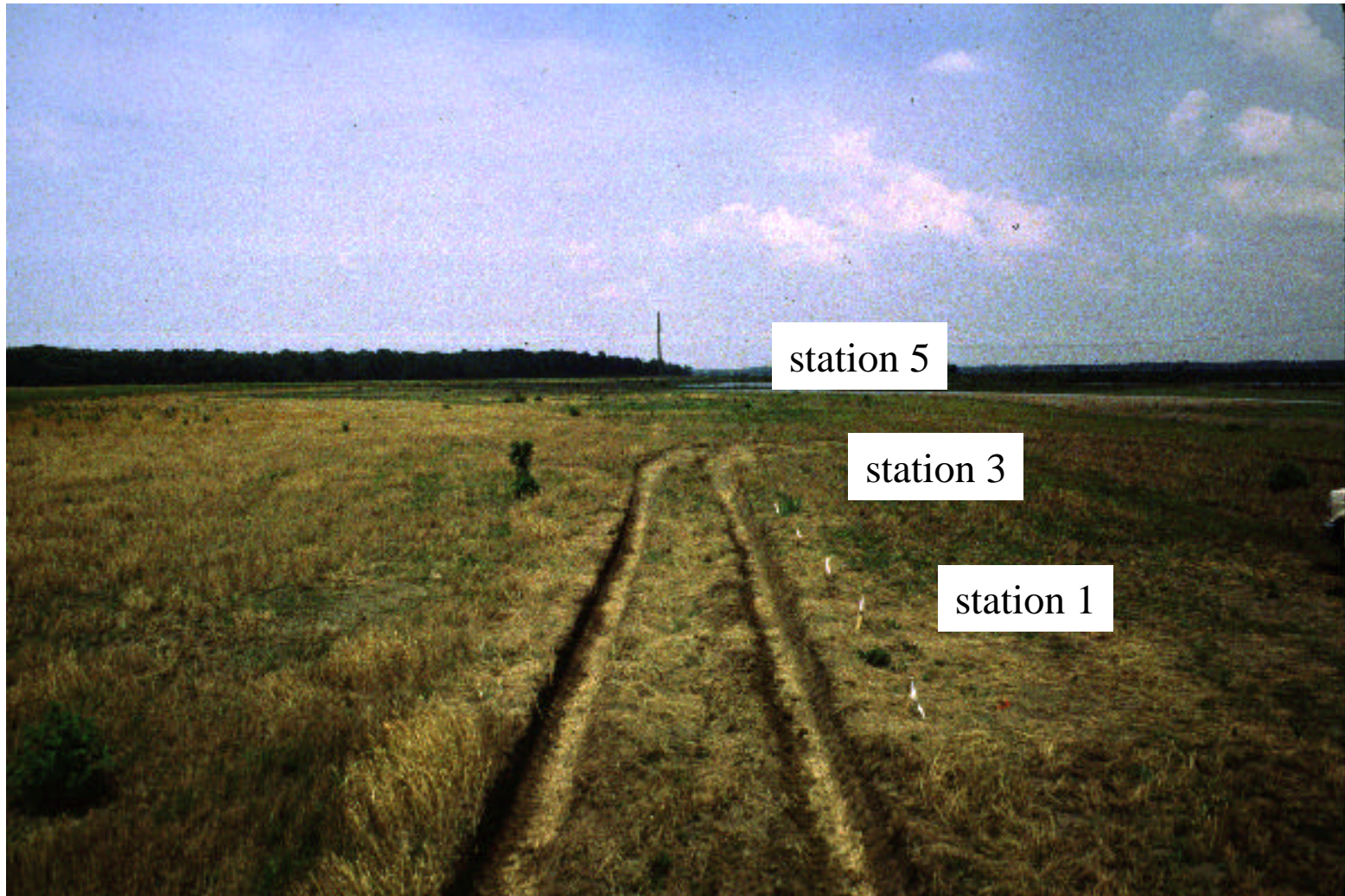
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<b>FACTORS</b>	<b>LEVELS</b>
<b>Soil Type</b>	<b>Clay, Silt, Sand</b>
<b>Vehicle</b>	<b>HMMWV (2), M1078, M923A2, M113A2, M2</b>
<b>Speed</b>	<b>Constant, Variable</b>



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## Typical course layout for data collection and validation testing







**M1078 used in validation testing**



**Rutting formed by M1078 used in validation testing**





# ***RMM: Field Tests***

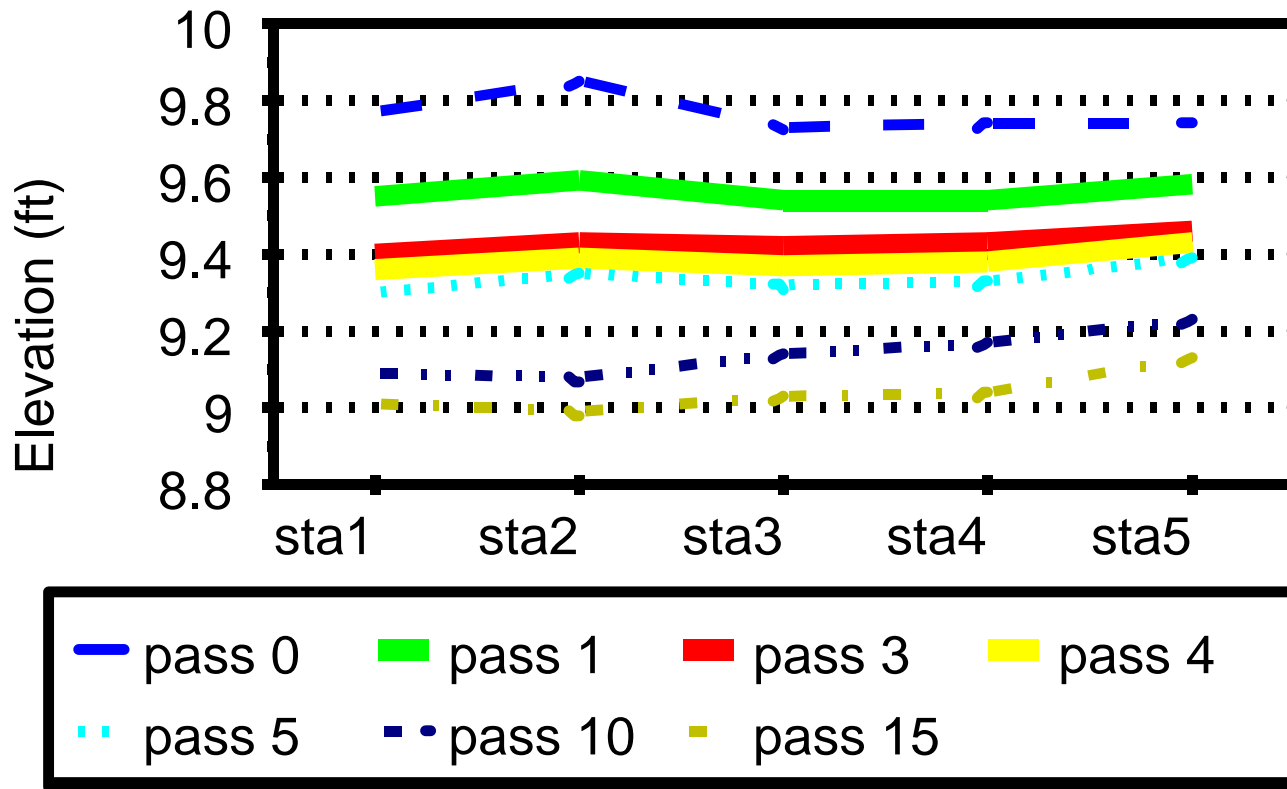
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- **The next 2 slides present sinkage data and corresponding cone index data collected during validation testing with the M1078**
- **Note: maximum sinkage (considering consecutive passes) occurs after the first vehicle passage**
- **Note: soil strength (cone index) increases with the number of passes**
- **Algorithms developed under the RMM program model resultant load, sinkage, motion resistance, traction, and slip for a specified vehicle traversing a deformable medium**

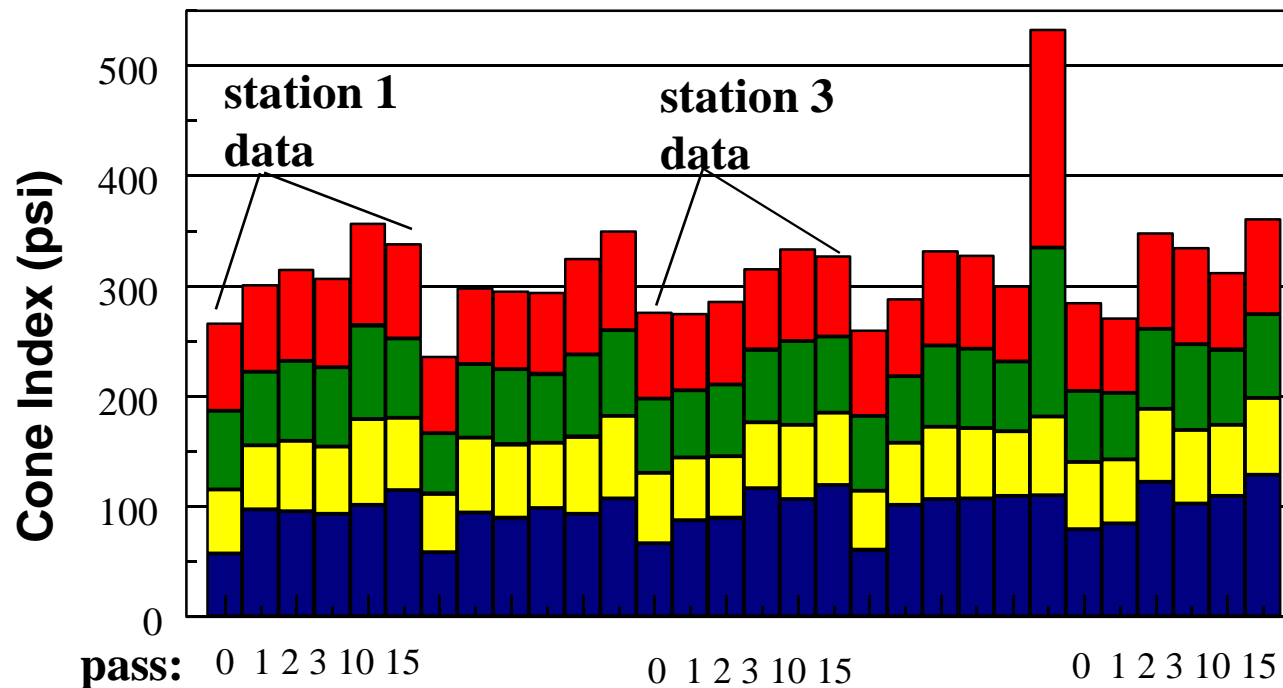


## Field Test: LMTV (M1078) Unloaded

Slow Speed Left Rut 5-21-96



## Field Test: LMTV (M1078) Unloaded Slow Speed Left Rut 5-21-96



soil depth (inches):





# Summary

- **Work effort will result in a capability to**
  - **evaluate off-road mobility at higher fidelity**
  - **support future research endeavors for virtual environments**
  - **explore vehicle design changes**
- **Algorithms portable to various vehicle dynamics platforms**
- **Methodology will**
  - **include dynamic mass**
  - **incorporate multi-pass representation**
  - **model mobility at less-than-maximum potential**

